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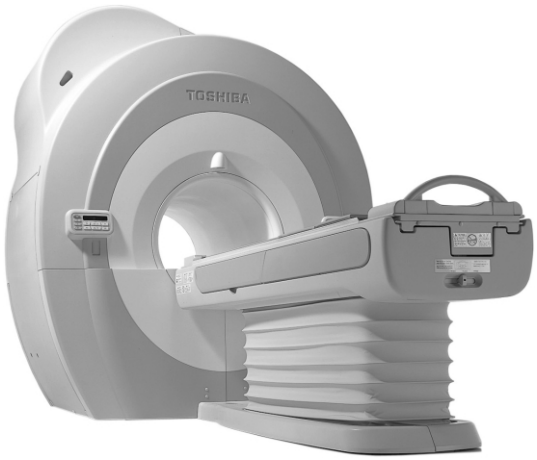
ULTRA-SHORT MAGNETIC RESONANCE IMAGING SYSTEM MRT-1504

Vantage Titan™

Product Data
No. MPDMR0235EAA

APPLICATION

Toshiba is proud to announce the addition of the Vantage Titan to our MR product line. The Vantage Titan combines the features of the Atlas technology with Open Bore technology to offer an unprecedented level of performance and patient comfort. The 71 cm patient aperture [1)] of the Vantage Titan and the ultra short 1.4 m magnet offer a field of view that is uncompromised at 55 cm x 55 cm x 50 cm. This level of performance was previously unavailable with an Open Bore system. The Vantage Titan combines a fully functional 1.5T with Open Bore technology and is truly the best of both worlds in one product.



ADVANTAGES [2)]

Vantage Titan - Patient friendly, uncompromised imaging

Featuring a 1.4 m ultra-short magnet, the Vantage Titan also offers Toshiba's proprietary noise reduction technology, Pianissimo™. The gradient noise is reduced for all imaging sequences and is always active. The Vantage Titan's 71 cm patient aperture [1)], ultra-short bore and Pianissimo offer the most patient friendly MR experience.

Outstanding clinical capabilities with superior image quality

Only Toshiba can offer a magnet this short, wide and quiet with uncompromised performance, field of view and homogeneity. In addition the Vantage Titan offers our robust Fat Free imaging, overall superb image quality and head-to-toe non-contrast MRA techniques.

Atlas SPEEDER™ technology opens up a new world of diagnosis

Powerful, fast, and easy – Vantage Titan features a new RF system and controller architecture. Featuring Atlas SPEEDER, Toshiba's new parallel imaging technology offering outstanding diagnostic versatility with streamlined workflow, set-up and acquisition are easily performed in all clinical studies, from routine examinations to advanced examinations such as whole-body scans.

1) The diameter of the narrowest part of the patient bore is 69 cm.
2) Some features may require optional packages.

COMPOSITION

Standard composition (Model: MRT-1504)

- 1.5-tesla actively shielded magnet with an active shield gradient coil
- Patient couch
- Wall cabinet
- Controller [1)]
  - – CPU cabinet [2)]
  - – Wide LCD color monitor
  - – Keyboard and mouse
  - – Control pad
  - – Control box
- RF amp cabinet
- RF cabinet with integrated array platform
- Transformer cabinet
- Refrigerator
- Gradient power supply and control cabinet
- RF coils
  - – QD whole-body coil
- Emergency run-down unit [3)]
- Heat exchanger [4)]
- Oxygen monitor
- Step-down transformer [4)]
- Line filter box for RF shield room
- Software
  - – F2 Edition PRO system software
  - – Pianissimo package
  - – Auto-Voice
  - – DICOM Basic License
  - – Storage SCU kit
  - – Print SCU kit
  - – DICOM Media kit
- Full set of accessories
  - – Operation manual
  - – Phantom
  - – Patient observation camera
  - – Patient call system
  - – Patient immobilization band
  - – Intercom system
  - – Safety training video
  - – Warning plates

Optional items

- Cardiac R6 package (MSSW-CFAR6) [5)]
- SuperFASE R6 package (MSSW-FASER6) [5)]
- MRA R6 package (MSSW-MRAR6) [5)]
- DRKS R6 package (MSSW-DRKSR6) [5)]
- EPI R6 package (MSSW-EPIR6) [5)]
- DTI R6 package (MSSW-DTIR6) [5)]
- JET R7 package (MSSW-JETR7/S1)
- Proton spectroscopy package (MRS-PRO)
- PC virtual filming package (MSSW-PCVFLM) [6)]
- PC transfer series web browser support package (MSSW-WEBSP) [6)]
- RF coils
  - – Atlas SPEEDER Head (MJAH-127A)
  - – Atlas SPEEDER Spine (MJAS-147A)
  - – Atlas SPEEDER Body (MJAB-157A)
  - – Rectangular Flex coil (MJLR-107F)
  - – ϕ70 Flex coil (MJLC-077F)
  - – ϕ100 Flex coil (MJLC-107F)
  - – ϕ150 Flex coil (MJLC-157F)
  - – ϕ200 Flex coil (MJLC-207F)
  - – QD head coil (MJQH-127A)
  - – QD knee/foot coil (MJQJ-147A)
  - – QD knee coil (MJQJ-107A)
  - – Circular coil holder for TMJ imaging (MJCA-147A)
  - – Breast mats for Flex coils (MJCA-177A)
  - – Shoulder array coil (MJAJ-107A)
  - – 4ch array adapter (MJCC-167A)
- Interactive cardiac gating unit (MKSU-ECGU04)
- Waveform display kit (MKSU-LCDK01)
- Peripheral gating package (MKSU-PPGK02)
- Respiratory gating package (MKSU-RSPK03)
- Second console (MKDN-010A)
- Atlas extended table travel (MZPT-1504) [7)]
- High-order shim kit (MZKT-HOSK04) [7)]
- DICOM
  - – Storage Commitment kit (MIDC-018A)
  - – Q/R SCP kit (MIDC-013A)
  - – Q/R SCU kit (MIDC-019A)
  - – MWM SCU kit (MIDC-016A)
  - – MPPS SCU kit (MIDC-017A)

1) The desk for the monitor, keyboard, and mouse is not included in the standard configuration.
2) The DVD-RAM disk drive is installed inside the CPU cabinet.
3) The remote emergency run-down switch is installed in the scan room.
4) These units are to be locally supplied. The model may differ depending on the country. The heat exchanger may be optional in some countries.
5) The requirements for each package are listed in the options list.
6) Not available in the U.S.A.
7) Factory option.

HARDWARE SPECIFICATIONS

Magnet

The Vantage Titan uses the world's shortest (1.4 m) self-shielded superconducting magnet. A wide patient aperture with 71 cm [1] minimizes patient anxiety, ensuring a comfortable examination environment for all patients.
Field strength: 1.5 T
Length: 140 cm

- Homogeneity
  - With passive shimming:
    2 ppm or less at 500 mm DSV (50 cm × 50 cm × 50cm)
    1 ppm or less at 400 mm DSV
    0.4 ppm or less at 300 mm DSV
    0.15 ppm or less at 200 mm DSV
    0.04 ppm or less at 100 mm DSV
    The above are VRMS (Volume root mean square) values based on measurements obtained by the precise 24-plane plot method. Twenty points per plane are measured.
- Shimming method
  - Passive shimming
    Homogeneity is optimized on site by the addition of ferromagnetic material inside the magnet bore during installation using a computerized procedure. This is a very stable optimization method that does not require regular maintenance.
  - AAS (Auto-Active Shimming)
    When a patient is placed in the magnet, the patient's body will affect the magnetic field homogeneity. AAS adjusts the homogeneity to ensure the optimal field uniformity for each patient and/or pulse sequence such as FatSAT, PASTA, and EPI.
- Magnet mass (including liquid helium): Approx. 4,000 kg
- Fringe field
  The magnet employs active shielding. The fringe field line at 0.5 mT (5 gauss) is at 3 m in radial distance and at 5 m in the axial direction from the center of the magnet. This permits flexibility in magnet siting.
- Stability of the magnetic field (bare magnet)
  The superconducting magnet provides an extremely stable magnetic field. Stability is 0.1 ppm/hr or better.
- Cryogen
  The integrated refrigeration unit eliminates liquid nitrogen usage and reduces the boil-off rate of liquid helium to approximately 0.05 [2] liters per hour.
- Operating panel on the magnet
  The operating panel supports the following operations to facilitate patient set-up and scanning: scan start, abort, and pause/resume, emergency table stop, laser light localizer ON/OFF, ventilation adjustment, lighting adjustment, and patient couch operation. The panel is also provided with a couch position display, interlock display, and system ready LED.

1) The diameter of the narrowest part of the patient bore is 69 cm.
2) This value is provided for reference only and was measured with no gradient pulsing. The actual value will vary depending on usage.

RF coils (T: Transmit RF, R: Receive signals)

- Standard RF coils
  The Vantage Titan features a full range of QD RF coils to cover a wide range of clinical requirements.
  - QD whole-body coil (T/R)
    This coil is integrated into the magnet cover. It provides a uniform RF field with QD transmission and a high SNR with QD reception. The internal diameter of this coil is 69 cm.
- Optional RF coils
  - Atlas SPEEDER Head (R) (MJAH-127A)
    14-element array design that is suitable for head and neck studies with optimal SNR.
  - Atlas SPEEDER Spine (R) (MJAS-147A)
    32-element array design that is suitable for spine studies with optimal SNR. This integrated coil design features the unique ability to slide up to 380 mm to permit routine feet-first imaging of the lumbar and thoracic spine.
  - Atlas SPEEDER Body (R) (MJAB-157A)
    16-element array design that is suitable for abdominal studies with optimal SNR.
  - QD head coil (T/R) (MJQH-127A)
    Provides a uniform RF field with QD transmission and optimizes SNR with QD reception. A detachable mirror is provided to minimize patient anxiety.
  - QD knee/foot coil (T/R) (MJQJ-147A)
    Designed to obtain high-SNR images of the knee, ankle, and foot. An extended coil element allows the foot to be held in a comfortable position during scanning while providing excellent SNR in the distal foot and toes.
  - QD knee coil (T/R) (MJQJ-107A)
    Design optimizes SNR and provides a uniform RF field with QD transmission and reception capabilities. The coil has a large diameter of 195 mm. The upper part of the coil can be opened to facilitate patient handling.
  - Rectangular Flex coil (R) (MJLR-107F)
    The coil loop is a rectangle with dimensions of approximately 18 cm × 36 cm and has a large sensitive area. The rectangular loop section is cushioned and flexible.
  - ϕ70 Flex coil (R) (MJLC-077F)
    The diameter of the coil loop is 70 mm. The circular loop section is cushioned and flexible.
  - ϕ100 Flex coil (R) (MJLC-107F)
    The diameter of the coil loop is 100 mm. The circular loop section is cushioned and flexible.
  - ϕ150 Flex coil (R) (MJLC-157F)
    The diameter of the coil loop is 150 mm. The circular loop section is cushioned and flexible.
  - ϕ200 Flex coil (R) (MJLC-207F)
    The diameter of the coil loop is 200 mm. The circular loop section is cushioned and flexible.
  - Shoulder array coil (R) (MJAJ-107A)
    A 4-channel array configuration provides excellent spatial and contrast resolution for the shoulder. This coil requires the 4ch array adapter (MJCC-167A)

– Bilateral TMJ imaging kit
  This requires two 70-mm Flex coils (MJLC-077F) and Circular coil holder for TMJ imaging (MJCA-147A). The positioning holder (included) allows stable and reproducible imaging of the TMJ bilaterally.
– 4ch array adapter (MJCC-167A)

Controller

The controller features a wide LCD color monitor, permitting multiple windows to be clearly displayed for true multitasking operation. It is ergonomically designed to allow operation in both the standing and sitting positions by a single technician.

- Display monitor
  The controller features a high-resolution 24" LCD color monitor. The display matrix is 1,920 × 1,200 with 256 B/W gradation levels.
- Control pad and control box
  The following operations can be performed using the hardware controls at the console: power ON/OFF, emergency stop, scan start, scan abort, scan pause/resume, couchtop movement and intercom talk and volume.
- Mouse
  Optical three-button mouse. All interfaces can be accessed by simple point-and-click operation except for registration of patient information and comments for image annotation.
- Keyboard
  The keyboard is used to register patient information and comments for image annotation.

Patient couch

The patient couch is ergonomically designed to maximize patient comfort as well as patient throughput. The couchtop can be lowered to 430 mm from the floor. Hydraulic drive ensures smooth and quiet vertical couchtop movement. Vantage Titan also has an extended table travel option (MZPT-1504) that increases the usable scanning range to 205 cm.
Maximum patient load: 200 kg

Computer system

The computer system is designed to provide outstanding multitasking performance, permitting image reconstruction and advanced image processing to be performed simultaneously with scanning. This helps to increase examination productivity. In addition, the computer system is provided with network connectivity for expandability.

- Host computer
  System manager (SM)
  CPU: Intel® Xeon® (Dual core Dual CPU system)
  Clock speed: 3.0 GHz or more
  Main memory capacity: 4 GB or more
  Hard disk drives: 2
  For system use: 73 GB (unformatted storage)
  For image data: 146 GB (unformatted storage)
  Image capacity: Approximately 560,000 images (256 × 256 images, raw data not saved)
- System control system
  Real-time manager (RM)
  CPU: 32 bit
  Memory capacity: 32 MB
  System control method: Distributed control
- Reconstruction system
  Maximum reconstruction speed : 4,400 images/second or more (256 × 256, FFT, potential)
  Simultaneous image reconstruction during scanning: Possible
  Reconstruction matrix: 1,024 × 1,024 (maximum)
  Main memory capacity: 12 GB or more
  Hard disk drive capacity: 2.2 TB (unformatted storage)
- DVD drive unit
  Storage capacity: 9.4 GB (unformatted storage)
  Saved image capacity: Approximately 48,000 images (256 × 256 images, raw data not saved)
- Connection with external devices
  Interface: Ethernet (1000Base-T)
  DICOM 3.0
- Cabinet
  Installation location: Computer room

Digital RF system 16

The Digital RF system consists of a digital transmitter and wideband 16-channel analog/digital receivers supporting array acquisition. The digital transmitter provides the precise RF phase control needed to employ advanced pulse sequences. The high-frequency data sampling capability supports fast scan techniques.

RF power amplifier

An output rating of 35 kW ensures that the system can generate the short pulses required for advanced pulse sequences. To ensure patient safety, RF power is emitted only when the SAR calculated by the system is below a preset limit.

Gradient subsystem

The combination of a powerful gradient power supply unit and a high-precision active shield gradient coil ensures stable image quality with all sequences, eliminating eddy currents.

	Vantage Titan
Gradient strength:	30mT/m
Slew rate:	130mT/m/ms
Gradient duty cycle:	100%

Toshiba's innovative Pianissimo technology is a patented gradient acoustic noise reduction technology that dramatically reduces scanning noise.

Patient comfort and safety

- The world's shortest open gantry (1.4-m magnet) with the largest clinical FOV markedly reduces patient anxiety and ensures comfort during examination.
- Pianissimo
  Pianissimo technology dramatically reduces the level of acoustic gradient noise, thus substantially enhancing patient comfort, especially during scanning with fast sequences.
- Lighting/Ventilation of the patient bore
  Adjustable lighting/ventilation improves patient comfort in the magnet during scanning.
- SAR calculation
  The system always calculates SAR before scanning. If the calculation result indicates that the preset limit will be exceeded, scanning cannot be started.
- Patient call system
  The patient call system allows the patient to signal an emergency during scanning. The system includes a handswitch that is actuated by the patient.
- Intercom system
  The integrated intercom system allows two-way communication between the patient and the operator.
- Patient observation system
  A CCD camera is used to observe the patient during scanning.
- Oxygen monitor
  The oxygen monitor automatically activates the customer-supplied ventilation system if the oxygen level falls in the scan room.
- Emergency run-down unit
  This safety switch allows automatic ramp-down of the magnetic field in the event of an emergency.

PERFORMANCE SPECIFICATIONS

Acquisition parameters

The Vantage Titan digital architecture offers extremely flexible acquisition parameters for optimizing image quality and scan times.

- Imaging method [1] : 2DFT and 3DFT
- Imaging nucleus: Proton (hydrogen nucleus)
- Slice orientations [1] : Axial, sagittal, coronal, oblique (single and double)

Refer to the scan parameter table.

Scan parameters [1) 2) 3)]	Specifications	Note
FOV [mm]	5 to 550	Adjustable in increments of 1 mm. The 550-mm FOV (550 mm in the X and Y directions) is used for purposes such as locator scanning.
Min.SliceThickness2D [mm]	0.5	Adjustable in increments of 0.1 mm.
Max.SliceThickness2D [mm]	100	
Min.SliceThickness3D [mm]	0.05	Adjustable in increments of 0.1 mm.
Max.SliceThickness3D [mm]	50	
Min. ETS (Echo Train Spacing)		
EPI	0.6	
FSE	2.6	
Max.Matrix	1,024	Independently adjustable in 16 or 32 steps in both the frequency and phase encoding directions.
– Frequency encoding:	64 to 1,024	
– Phase encoding:	32 to 1,024	
Highest In-Plane Resolution [μm]	20	
Maximum number of slices (2D)	128	
Maximum number of slices (3D)	256	
Number of acquisitions (NAQ):		
– Integer NAQ:	From 1 to 64	Adjustable in increments of one (1, 2, 3, 4, 5, 6, and 7, etc.)
– Variable NAQ:	Available	Adjustable increments of 0.1 from NAQ=1 (NAQ = 1.1, 1.2, etc.)
– AFI (Advanced Fourier Imaging)	Available	Scan time reduced by approximately NAQ=0.5
TI (Inversion time):	9 ms to 10 s	
Flip angle:	1° to 180°	
Flop angle:	30° to 180°	

SPEEDER function

Speed-up factor: Max. 16X [4]

1) Specifications vary depending on the pulse sequence.
2) With optional MRA R6 package.
3) With optional EPI R6 package.
4) The factor depends on the coil and the number of RF channels used.

Imaging techniques and parameters

A wide range of imaging techniques are provided to complement the Vantage Titan's precise and powerful digital RF system, computer platform, and high-performance gradient subsystem.

- Conventional pulse sequences
  - SE (spin echo)
  - FE (field echo)
  - IR (inversion recovery)
- Fast scan techniques
  - FastSE
    Up to a 37-echo sequence can be specified. The flop angle for 180° RF pulses can be varied to reduce saturation transfer contrast (STC) effects and the specific absorption rate (SAR) to ensure patient safety. FastSE is compatible with both 2DFT and 3DFT. Flow compensation and presaturation are available.
  - FastIR
    An inversion pulse is added to the 2DFT FastSE technique to enhance T1 contrast. This results in a much shorter scan time than in conventional IR. Multislice is available.
  - FastFLAIR (fluid-attenuated IR)
    Increases contrast between fluids, such as CSF, and lesions to improve specificity using FastIR with a long TI, TE, and TR. This results in a much shorter scan time than in conventional IR. Multislice is available.
  - FastSTIR
    Suppresses fat signals using FastIR with a short TI. This results in a much shorter scan time than in conventional STIR. Multislice is available.
  - FastFE
    A pre-pulse is applied prior to FE pulse sequences to enhance T1 contrast with short scan times.
    Segmentation of scans is available to increase spatial resolution.
    FastFE is applicable to both 2DFT and 3DFT.
- Advanced fast scan techniques
  - FASE (fast advanced spin echo)
    This pulse sequence, which is based on FastSE with a large number of echoes (max. 276 ETL), is combined with advanced Fourier imaging (AFI) to reduce the scan time significantly with an echo factor of 512 (scan time reduction factor) in the standard configuration or 1,024 with optional software. A single shot is sufficient to generate an image in a few seconds. A pre-pulse is available for fat suppression. This technique is compatible with both 2DFT and 3DFT. FASE provides T2-weighted images and is an RF refocused echo planar imaging (EPI) technique. High contrast is achieved. T2-weighted images with short scan times can be used to clearly depict the gallbladder, hepatic ducts, and pancreatic duct without contrast agent. FASE expands the range of clinical applications of MRI, supporting magnetic resonance cholangiopancreatography (MRCP), MR urography, and MR myelography.
  - The optional SuperFASE package supports an expanded range of clinical applications such as fresh blood imaging (FBI) or swap phase encode extended data acquisition (SPEED).
  - Hybrid EPI (echo planar imaging)
    The Vantage Titan has Hybrid EPI capabilities to support the use of up to 60 echoes each with a different phase encoding similar to FastSE. Hybrid EPI uses a combination of both FastSE and EPI data, providing T2-weighted contrast while reducing SAR.
  - Multi-Shot EPI
    Utilizes gradient echoes for EPI, which are divided by up to 15 echo factors for one acquisition. Multislice is available.
  - Single-Shot EPI
    Both SE type and FE type are available. FE-type Single-Shot EPI requires the optional EPI package.
  - TrueSSFP
    T2-/T1-contrast images can be obtained quickly using the steady-state free precession technique. This is suitable for scanning relatively longer T2 tissues and vascular structures during breath-holding. Fat saturation is possible by dividing scans into multiple segments.
  - FSE/FASE T2 Plus
    By promoting transverse magnetization recovery in FSE and FSE 2D, the scan time can be reduced and the resolution can be increased with no loss of T2 contrast and SNR.
  - SSFP
    T2-/T1-contrast images can be obtained quickly using the steady-state free precession technique. This is suitable for imaging relatively longer T2 tissues such as CSF and synovial fluid. The slice thickness can be reduced by 3DFT scanning.
- Advanced pulse sequences
  - MR Fluoroscopy
    Continuously acquires and reconstructs data and displays the reconstructed image in near real time. The slice orientation and slice position can be changed interactively during scanning.
  - Real-time locator
    An advanced application of MR fluoroscopy that acquires axial, coronal, and sagittal planes and reconstructs and displays the data in real time to facilitate patient positioning.
- JET technique
  JET acquires the data for the k-space in non-cartesian mode and suppresses motion artifacts by detecting and correcting for in-plane motion using the data for the central part of the k-space, which is acquired repeatedly. This application can suppress not only image artifacts in patients who are unable to remain still during scanning, but also artifacts due to involuntary motion such as CSF flow. This technique is based on FastSE 2D, and uses T2W and FLAIR contrast enhancement.

- Vascular imaging techniques
  - 2D-TOF (time of flight)
    The time of flight effect is induced by the in-flow of fresh spins into the imaging slice to differentiate blood flow from tissue. Slices are acquired sequentially through the imaging volume. This technique functions optimally when the vessels are perpendicular to the acquired slices. It depicts relatively slower blood flow and is suitable for cervical, abdominal, and extremity applications. Maximum intensity projection (MIP) images can be displayed from multiple viewing angles. An overlapping scanning technique improves the visualization of vessels. A moving presaturation band can also be applied to differentiate between arterial and venous flow in certain body areas. ECG gating is applicable for 2D-TOF*
  - 3D-TOF (time of flight)
    3DFT with TOF is used to depict multidirectional vascular structures and faster blood flow. MIP images can be displayed from multiple viewing angles. SORS-STC and ISCE RF pulses can be combined with 3D-TOF to improve vessel detail.
  - 3D-CE (contrast enhanced [5])
    Contrast agent is injected in order to enhance blood signals, followed by a 3D-FE or 3D-FastFE sequence.

    5) Disclaimer: In the USA, the FDA limits the use of contrast agents to certain applications.
  - SORS-STC (slice-selective off-resonance sinc pulse saturation transfer contrast)
    Enhances blood flow and suppresses background signals by using a slice-selective off-resonance pulse. SORS-STC is more effective than conventional spatially nonselective STC (or MTC) because it suppresses background tissues without reducing the signals from bloodflow.
  - ISCE (inclined slab for contrast enhancement)
    Provides increased vessel detail by using an RF pulse with a different flip angle in combination with 3D-TOF to enhance signals from blood flow throughout the imaging volume.
  - Multi coverage
    Separates the data acquisition area of 3D TOF MRA into a few regions in order to limit signal reduction due to saturation effects.
  - 2D-PS (phase shift)
    The phase shift effect is generated by applying a flow encoding gradient pulse. The phase shift is proportional to the flow velocity. 2D-PS can be used with a volume slice to increase coverage of vessels and shorten scan times. Selecting the flow velocity allows specific vessels to be depicted.
  - Cine 2D-PS (phase shift)
    2D-PS can be used with an optional cardiac-gating unit for cine imaging.
  - Flow Quantification
    Blood flow velocity can be measured using cine 2D-PS with an optional cardiac-gating unit.
  - 3D-PS (phase shift)
    The phase shift effect, when used with 3DFT, is suitable for showing multidirectional vascular structures. Selecting the flow velocity allows specific vessels to be visualized. MIP images can be displayed from multiple viewing angles.
  - BEST (blood vessel enhancement by selective suppression technique)
    A postprocessing algorithm that selectively enhances small vessel detail and suppresses background tissue signals.
  - Cardiac tagging*
    Allows myocardial movement to be visualized by applying several presaturation bands. Optional ECG gating is required. The number and positions of tags can be selected.
- Fat suppression techniques
  The Vantage Titan includes a comprehensive selection of fat suppression techniques to support a wide range of applications.
  - STIR (short TI inversion recovery)
    A short TI 180° pre-pulse with IR suppresses fat signals to enhance water-proton images.
  - FastSTIR
    STIR with FastIR to reduce scan times.
  - WFOP (water/fat opposed phase)
    An asymmetric SE technique in which image acquisition is performed at the instant the signals from water and fat go out of phase.
  - FatSAT (fat saturation)
    Fat saturation pulses are applied to presaturate fat only. The multislice off-resonance fat suppression technique (MSOFT), an innovative Toshiba technology, ensures uniform fat suppression over all slices by using an offset RF pulse for each slice. Offset values are determined based on data acquired by auto-active shimming.
  - PASTA (polarity altered spectral and spatial selective acquisition)
    Another innovative technique for suppressing fat signals in SE and FastSE sequences to obtain uniform water images over all slices. It consists of a narrow-bandwidth 90° RF pulse to separate water from fat. Opposing slice gradient polarity is used for 90° and 180° RF pulses to refocus water signals.
  - DIET (dual interval echo train)-FastSE
    A drawback of FastSE is the high brightness levels from fat tissue signals. DIET is a new technique that reduces fat signals in FastSE by utilizing a pulse sequence with irregular echo intervals to achieve contrast near SE levels.

* option

- Imaging modes
  - Multislice
    Multiple slices can be acquired during a scan.
  - Multi-echo
    Multiple echo data can be acquired within a single TR.
  - Multi-coverage
    If the specified number of slices cannot be acquired within the designated TR, the system automatically repeats the scan to cover the required area.
  - Interleaved scan
    Excites odd slices first and even slices second to eliminate interslice interference.
  - Excitation order for multislice
    The user can select the order of excitation in multislices as follows.
    · Forward (from small to large numbers)
    · Reverse (from large to small numbers)
    · Concentric (from center to outside)
  - Dynamic scan
    Sets up to five continuous dynamic scans in one study. Each dynamic scan is specified independently according to the delay time, scan interval, and number of scans. The minimum scan interval is zero.
  - Gating
    · Cardiac gating
    Multislice/single-phase and single-slice/multiphase imaging techniques are available. Cardiac images can be displayed in cine mode. Retrospective gating is also available as an option.
    · Peripheral pulse gating*
    Reduces CSF pulsation artifacts.
    · Respiratory gating*
    Reduces respiratory motion artifacts.
- Artifact suppression techniques
  - Flow compensation
    Utilizes gradient moment nulling techniques to reduce flow artifacts.
  - Presaturation
    Up to seven presaturation bands can be set to reduce motion, flow, and wrap-around artifacts. The Vantage Titan's graphical user interface allows multiple bands in the orthogonal and oblique directions to be set with ease. The following preset presaturation bands are available.
    · Anti-phase aliasing
    · Anti-frequency aliasing
    · Flow suppression
    · Leading or following slices (for 2D-TOF)
  - Skipping SAT*
    Reduces the number of presaturation pulses in order to increase the number of slices.
  - No wrap (frequency and phase directions)
    Eliminates wrap-around artifacts by increasing the sampling data points in frequency or encoding steps in phase. The no wrap function is applicable up to a 512 × 512 matrix with 3DFT.
  - Phase swap
    The phase and frequency encoding directions can be swapped to minimize flow and respiratory motion artifacts.
  - Breath-hold imaging
    An optional Auto-Voice function instructs patients when to hold their breath.

User interface

The new CPU platform provides supercomputing power as well as an operator-friendly graphical interface to ensure simple and fast system operation. The standard 24" wide-screen LCD flat panel color monitor enhances the true multitasking capabilities of the system by facilitating multiple-window operation. In addition, the Vantage Titan offers simple scan mode, one of the industry's most advanced forms of operator-friendly interfaces for simple operation.

- Patient registration
  - Patient register
    Comprehensive patient information can be stored, including radiologist name, referring physician, department, and operator. Scan protocols, RF coils, and patient orientation can also be preregistered.
  - Calendar function
    Simplifies patient scheduling and scan reservation by displaying a calendar with information concerning preregistered patients.
- Sequence control
  - Sequence queue
    Operators can easily and effortlessly set scanning conditions by simply retrieving the conditions from "Sequence memory" or by specifying each parameter using a sequence editor. Scans can be initiated automatically or manually.
  - Sequence memory
    Preprogrammed selection of scan protocols categorized by anatomical region using easily understandable icons. Scan protocols can be preset using the sequence editor.
  - Sequence editor
    Allows the operator to optimize the desired pulse sequences by updating all scan parameters interactively based on the operator's input.
- Image display
  - Display window
    Displays images from the selected patient study. A display toolbar consists of multiple icons that provide quick access to the most frequently used display functions. The size of the display window can be adjusted.
  - Image matrix
    Allows the operator to view all images in a patient study at a glance. This unique image search function automatically appears with the display window. It shows all images in miniature size in a single window. Images are arranged in the matrix by scan and slice position.

* option

– Window adjustment
Automatic or manual using the mouse or rotary controls.
– Labeling
User-selected information can be placed on the image as annotations in various formats.
– Multiframe display
Multiple images can be displayed within a single window. Several formats are available and can easily be selected using icons on the display toolbar.
– Inset view
Shows a reference image that indicates the position of the displayed slice. The reference image is displayed in miniature size in one corner of the display window. The location is user-selectable. The reference image can easily be swapped with the displayed image to facilitate diagnosis.
– Cine display
Sequentially displays an image data set. It can be used for MR vascular images, cardiac studies, and motion studies and is easily initiated by an icon located on the display toolbar. The maximum display speed is 15 fps.
– Interactive zooming
A graphic slider in the display toolbar allows the operator to zoom images interactively. The zoom function can also be controlled by preset icons or a pop-up menu. User-selectable interpolation algorithms such as nearest neighbor, bilinear, and spline are available.
– Image scrolling
Pans the displayed image by simple mouse operation.
– Image transformation
Rotates and flips the displayed images with a single click.
– Apply view
After zoom, scroll, flip, or rotate is performed for the displayed image, the same display functions can be applied to any selected images in the image matrix by a single click on an icon provided on the display toolbar.
– Apply contrast
After the window level and width are adjusted in the display window, the same adjustments can be applied to all selected images in the image matrix by a single click on an icon provided on the display toolbar.
– Graphics editor
Provides the following functions using an icon provided on the display toolbar.
· Text
Writes text on the displayed image.
· Drawing
Draws lines, rectangles, ellipses (including circles), multisegment lines, polygons, freehand curves, and angles on the displayed image.
· Cut, copy, and paste
The above text and graphics can easily be cut, copied, and pasted on the displayed image.
· Measurements
Measures the mean value, standard deviation, maximum and minimum values, number of points, FWHM (full width half maximum), distance, angle, ROI (region of interest) area, and edge spread for ROIs designated by the drawing function.
· Profile/Histogram
Shows a pixel intensity profile for designated lines and histograms (intensity vs. frequency) for ROIs such as rectangles, circles, etc.

• Scan planning
Scan planning allows simplified, fast, and accurate operation of the system.
The scan plan window is accessed from the "Sequence queue". It permits subsequent scans to be planned graphically with respect to slice position and orientation, TR, slice thickness, number of slices, slice gap, number of scans (multi-coverage), presaturation, etc. Scan planning can be performed using a single image, 2 parallel images, or up to 3 orthogonal images.

• Filming
The Vantage Titan's digital platform supports virtual filming by clicking an icon on the display toolbar.
– Virtual filming
The images to be filmed are displayed on virtual films in a filming window. Multiple film layouts are available. All selected images in the image matrix are copied to sequential frames on the virtual films by a single click. The images and layout on the virtual films can easily be revised or deleted. Once the virtual films are finalized, a single click generates the actual films in background mode on a laser imager.
– Film queue
Shows the current status of the actual printing process in background mode. Filming jobs can easily be canceled, deleted, or resubmitted.
– Masking
Hides a portion of the displayed image based on user-defined rectangular or circular ROIs.

• Utilities
Allows setup and monitoring of various functions for system administration and configuration.
– Patient registration format
– Liquid helium level
– Battery backup for UPS
– Job processing status
– Automated QA
– Error view

Image processing

The Vantage Titan's platform supports a wide range of high-speed image processing capabilities.

- Reconstruction
  The maximum reconstruction matrix is 1,024 x 1,024.
  – FINE
    Doubles the reconstruction matrix to improve spatial resolution without increasing scan times.
  – Mid-Slice
    Doubles the number of slices for the same slice thickness. The slice position is shifted by one half the slice thickness to avoid partial volume effects.
  – Refine filter
    User-selectable reconstruction filter to enhance image quality.
- Batch multiplanar reconstruction
  Provides oblique and curved reconstruction as well as interactive MPR.
- Batch MIP (maximum/minimum intensity projection)
  Projects maximum or minimum pixel intensity in a volume data set to provide comprehensive anatomical detail. It can be used for vascular imaging, MRCP, etc. Batch MIP is performed with true multitasking and can be processed during subsequent scanning. An independent workstation is not required. One projection is calculated within 1 s for a 256 × 256 × 64 data set. Fine MIP (using an original image with a matrix size up to 512 × 512) and target MIP are available. Optional software provides further enhancement with the STAMD method and Composite MIP.

Networking

- DICOM 3.0
  The Vantage Titan supports DICOM 3.0 for transferring image data over networks.
  The system is provided with the DICOM Basic license, Print SCU, Storage SCU, and DICOM Media as standard. In addition, Storage Commitment, Query/Retrieve SCP, Query/Retrieve SCU, MWM SCU, and MPPS SCU are available as options.
  IHE profiles are supported.
- Laser camera
  Specified laser cameras can be connected by Ethernet using the Toshiba digital protocol based on the ACR/NEMA standard. DICOM Print is also available.
- Second console*
  This console includes an independent computer platform and supports all of the functions of the main system console except for scanning and reconstruction. DICOM is supported, and the second console is connected to the system console by Ethernet. The use of an independent platform means that the main and second consoles can be used simultaneously for different tasks.
- Remote Service maintenance
  The InnerVision remote service system permits system diagnosis over a digital connection to the Toshiba Technical Support Center. Please consult your Toshiba representative for details.

SPECIFICATIONS OF CLINICAL APPLICATIONS

TOF MRA method

Blood vessels can be visualized without contrast medium using the time of flight effect.

- 2D TOF method
  Artery/vein separate: MovingSAT available
  Fat saturation method: Can be used in combination
  Presaturation method: Can be used in combination
- 3D TOF method
  – SORS-STC method:
    The imaging capabilities for blood vessels are improved by selectively suppressing the signals from tissues.
  – Flip angle of SORS-STC pulse: Variable
  – Head MRA scanning coil (QD head coil):
    Transmission and reception type
    (slice-selective off-resonance sinc pulse saturation transfer contrast)
  – ISCE method
    Degradation in peripheral blood vessel images is suppressed.
  – Selection of flip angle distribution in slab: Available
  – Combined use of SORS-STC method: Available
    (inclined slab for contrast enhancement)
  – Multicoverage method
    This is a wide-range imaging method taking advantage of the TOF effect using a thin slab.
  – Coverage joint suppression method: Available
  – Fat saturation method: Can be used in combination
  – Presaturation method: Can be used in combination
  – Support for Pianissimo Plus: Standard

Noncontrast MRA* by the FASE method

- FBI (fresh blood imaging) method*
  This is a vascular imaging method in which new blood ejected from the heart is visualized by setting an appropriate delay time from the R wave using ECG gating and peripheral pulse gating and performing data acquisition synchronized for each shot.
  – ECG-Prep method*
  – Intermittent breath-hold method in ECG-gated scanning
  – Sequential FASE method*
- SPEED (swap phase encode extended data) method*
  Blood vessels that run through multiple orientations are observed on one image by acquiring two images in which the phase encode direction is rotated by 90° and superimposing them using composite MIP processing*.
  – Automatic composite MIP

* option

PS MRA method
The PS (phase shift) method performs visualization based on the phase differences between moving parts and stationary parts.

- 2D PS method:
  Visualizes the blood vessels in a short time.
  – Scan cross section: Three orthogonal planes
- 3D PS method:
  Covers the slice range continuously without slice gaps.
  – Scan cross section: Three orthogonal planes

MRCP
The bile and pancreatic ducts can be visualized noninvasively using the FASE method (MR cholangiopancreatography).

- 2D MRCP method
  Visualizes the bile and pancreatic ducts in a short time.
  – Single-shot scan: Available
  – Multislice scan: Available
  – Fat saturation method: Can be used in combination
  – Support for Pianissimo Plus: Standard
  – Support for T2 Plus: Supported*
- 3D MRCP method
  Covers the slice range continuously without slice gaps.
  – Fat saturation method: Can be used in combination
  – Support for breath-hold scan: Automatic instruction by Auto-Voice
    Respiratory gating: Can be used in combination
  – Support for Pianissimo Plus: Standard
  – Support for T2 Plus: Supported*

Other types of MR hydrography
FASE and FastSE can be used in various clinical applications such as MR cisternography, MR myelography, MR urography, and MR lymphangiography.

Flow velocity measurement method
- Scan for flow velocity measurement
  – Method: 2D cine PS method
  – Cross section: Three orthogonal planes
  – Direction: Slice/readout/phase encode
- Flow velocity analysis
  Generation of flow velocity time curve

Diffusion Imaging
Isotropic diffusion-weighted images and ADC images can be obtained using the EPI and the FASE method.

- EPI Diffusion
  – Single-Shot EPI: Available
  – Three-axis continuous acquisition: Available*
- FASE Diffusion*
  – Three-axis continuous acquisition: Available*
- Diffusion postprocessing*
  – Diffusion ADC image
    (apparent diffusion coefficient image)
  – Diffusion isotropic image
    (isotropic diffusion-weighted image)
  – Dynamic averaging function: Available
  – Automatic postprocessing: Available (ADC, isotropic)

Diffusion Tensor Imaging (DTI)*
Continuous white matter tracts running in various directions in the head can be visualized using the EPI method.

- EPI Diffusion
  – Single-Shot EPI: Available
- Diffusion postprocessing
  – Fractional anisotropy image (indicating the degree of diffusion anisotropy)
  – Lambda image (characteristic value image)
  – Lambda image (vector image of characteristic value)
  – Dynamic Averaging: Available

Perfusion Imaging
ASL imaging using the ASTAR method without contrast medium can also be performed.

- ASL*
  – ASTAR method: Available
    The signals from static tissues are suppressed by canceling the MT effect by setting the IR pulse positions asymmetrically and also by suppressing the blood flow from one of the imaging slices.
  – Control IR position: Variable
  – Tag IR position: Variable
  – Tag IT thickness: Variable

* option

Cardiac Imaging

Various types of cardiac imaging can be performed by the combined use of the ECG-gating method.

- Cine imaging
  – Application: FE 2, FFE 2D (support for TrueSSFP)
  – Sequential multislice multiphase
  – Number of phases: Variable (depending on the R-R interval)
  – ECG-gating : Prospective, retrospective*
- ViewShare reconstruction: Available
  – Tagging scan: Available
  – Freehand tag: Tag thickness can be set.
  – Parallel tag: Tag pitch can be set.
  – Radial tag: Number of tags and tag angle can be set.
- BB (black blood) method*
  – Application: FASE 2D
  – Sequential multislice
  – Number of slices per breath-hold can be specified.
  – Fat saturation pulse can be used in combination.
- Cardiac function analysis*
  – Target: RAO image, 4-chamber image
  – Cardiac output (CO), ejection fraction (EF)
  – Volume curve is generated and displayed.
  – Percent wall thickness is calculated and displayed.
- Retrospective*
  – Acquires continuous cine images.
  – An image of the entire cardiac cycle, including diastole, can be obtained.
  – Application: FFE 2D (support for TrueSSFP)
- Myocardium delay imaging*
  – A T1-weighted image obtained using the inversion recovery method.
  – Application: FFE 2, FFE 3D
- Real-time motion correction (RMC)*
  An image with reduced respiratory motion artifacts can be obtained by following the scanning cross section relative to diaphragm motion. FFE 3D is applied.

INSTALLATION CONDITIONS

Power requirements

A continuous and stable power supply is required for reliable operation of the system. Frequent power failures may damage the system. The power line shall be free of rapid variations and must not be shared by other equipment.

Line voltage [1)]	200 V	400 V
Phase	Three-phase	Three-phase
Voltage fluctuation	±10%	+6%/-10%
Frequency	50/60 Hz ±1%	
Power requirements [2)]	45 kVA	42 kVA

1) Two line voltages (200 V and 400 V) are required for the system itself.
   Other line voltages may be supported with the use of an additional step-down or step-up transformer. Please consult with your local Toshiba representative and refer to the site planning manual for details.
2) An additional 15-20 kVA is required for the water cooling system.
   Continuous power (day and night) is required for some equipment.

Grounding

Independent grounding is required. Grounding must be provided in accordance with all applicable legal requirements for medically used electrical equipment.

Power consumption and heat dissipation (50/60 Hz)

Power consumption	52.8/53.2 kW
System heat dissipation	14.3/14.8 kW

Note: The heat dissipation value does not include the external heat exchanger.

Air conditioning

An appropriate air conditioning system is required to maintain the specified temperature and humidity. Continuous air conditioning (day and night) is required for some equipment.

* option

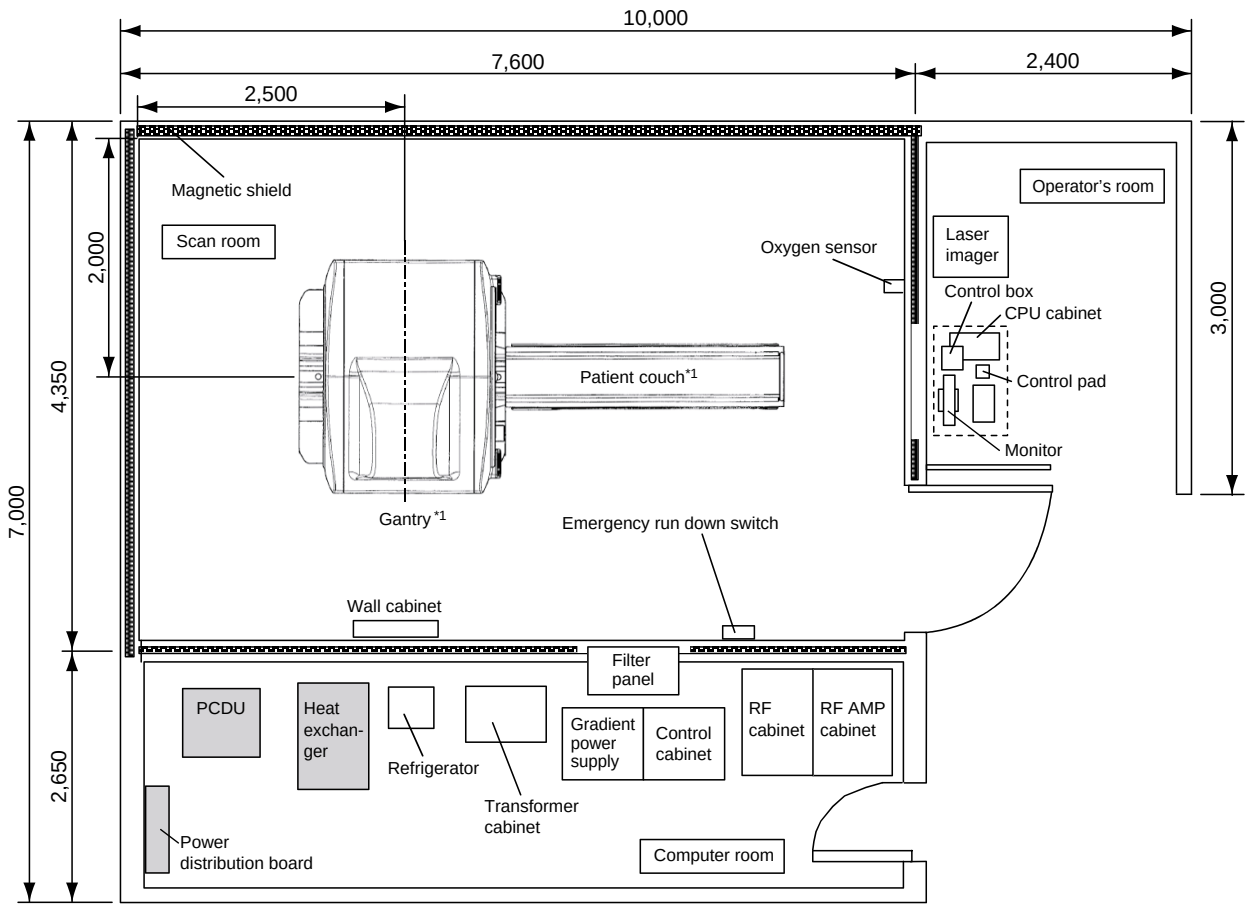
Environmental requirements

- Temperature and humidity: No condensation
  - Scan room: 16°C to 24°C, 40% to 60% R.H.
  - Control room: 16°C to 30°C, 40% to 75% R.H.
  - Equipment room: 20°C to 24°C, 40% to 70% R.H.
- Temperature fluctuation: -3°C/8 hr or less
- Magnetic field: Less than 1.0 µT peak-to-peak
- Electric field: Less than - 5 dB µV/m (0.56 µV/m) over 63.9 MHz +/- 0.5 MHz
  An RF shield room with more than 90-dB shielding is required.
- Ventilation: 30 m^3 /min or more for the scan room
- Ventilation pipe: A ventilation pipe must be provided in the scan room for emergency quenching of the magnet.
- Rigging clearance: 2.3 m (W) × 2.5 m (H) or more
- Minimum installation area: 40 m^2 (Net 34 m^2)
  - Scan room: 6.0 m x 3.9 m = 23.4 m^2
  - Control room: 2.7 m x 2.0 m = 5.4 m^2
  - Equipment room: 2.7 m x 4.0 m = 10.8 m^2
- Ceiling height: 2.4 m for the scan room, except for the maintenance space for the refrigerator (2.8 m)
- Maximum floor loading: 6.7 tons for the scan room
- Installation altitude: Less than 2,000 m above sea level
- Cooling water
  - Flow rate: 48 l/min or more
  - Temperature: 18°C to 22°C

DIMENSIONS AND MASS

Unit	Dimensions W × D × H mm	Mass kg
Magnet assembly	2,050 × 1,940 × 2,410	5,265
Patient bore length	1,495	
Couch	610 × 2,420 × 430 to 845	320
Wall cabinet	725 × 150 × 1,500	20
Controller		
CPU cabinet	215 × 655 × 435	22
Monitor	570 × 230 × 480	12
Control box	280 × 310 × 85	3
Control pad	130 × 145 × 75	1
RF cabinet	615 × 960 × 1,890	300
RF AMP cabinet	615 × 960 × 1,890	540
Gradient power supply and control cabinet	1,210 × 650 × 1,900	950
Refrigerator	450 × 450 × 600	90
Transformer cabinet	690 × 750 × 1,090	260
Accessary		490

LAYOUT EXAMPLE



*1: Applicable for use in the patient environment

Unit: mm

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